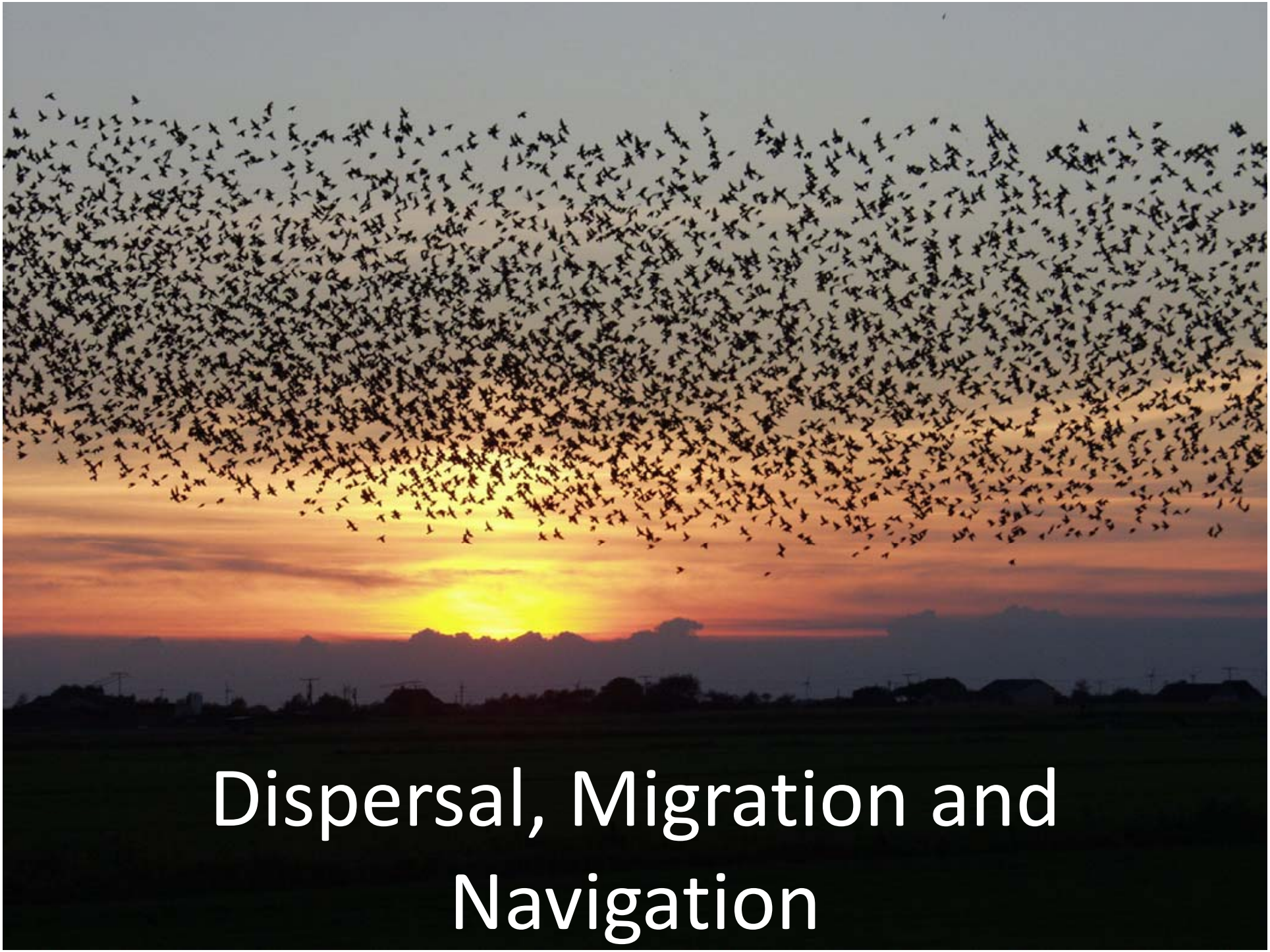


Dispersal, Migration and Navigation

What is animal dispersal?

Animal movement away from an existing population/ natal location.

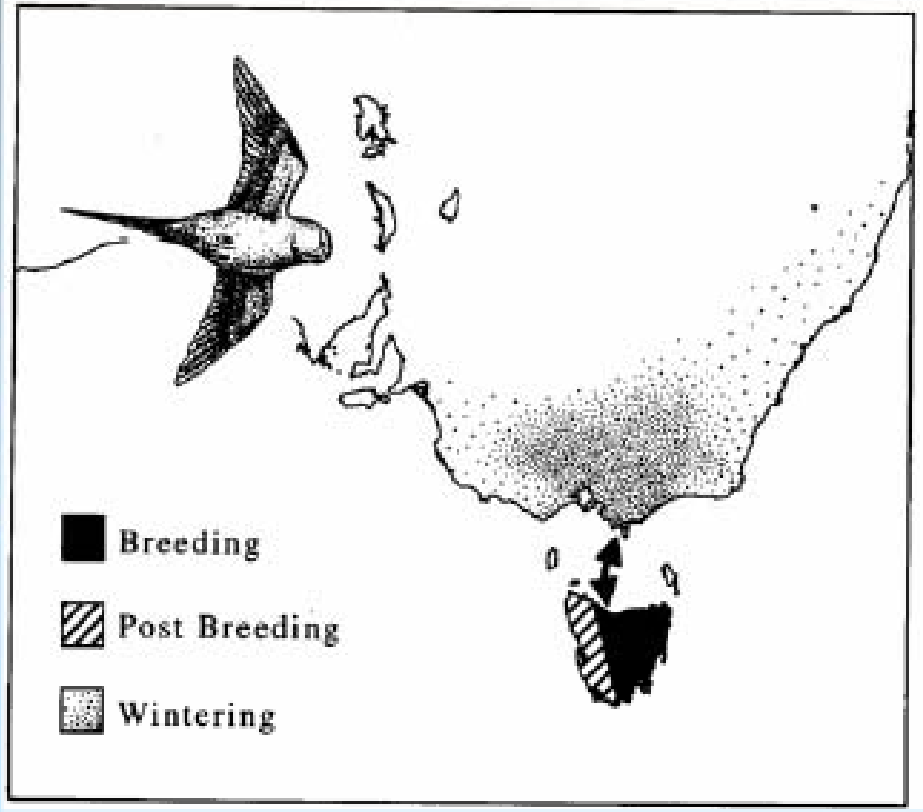
DISPERSAL:

1. Natal dispersal = permanent movement an individual makes from its birth site to the place where it reproduces.

2. Breeding dispersal = movement of adults between breeding attempts

Swift Parrot

Dabb/COG



Migration: The Biology…/*Oxford U.P.*

Why animals disperse?

Ultimate factors responsible for dispersal:

1) Inbreeding avoidance
2) Competition for mates
3) Competition for resources (e.g., breeding territories)

Sex-biased dispersal

Among birds, the predominant dispersing sex is the female.

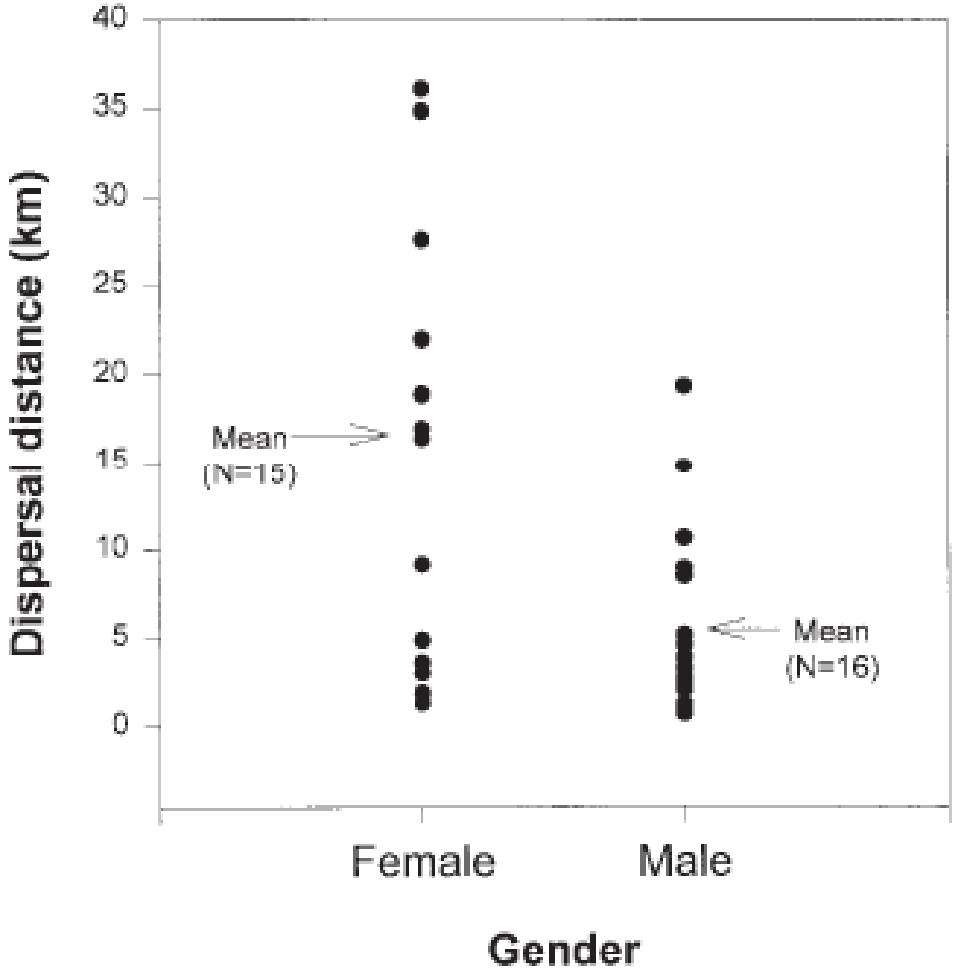


Figure 1.—*Dispersal distances from the natal area to apparent overwintering sites of female (N = 15) and male (N = 16) Western Screech-owls in southwestern Idaho in 1994 and 1995.*

Sex-biased dispersal

Among birds, the predominant dispersing sex is female.

Among mammals, the predominant dispersing sex is male.

Why?

Ground squirrels

Sex-biased dispersal

Among birds, the predominant dispersing sex is female.

Most birds are monogamous and territorial: greater need for males to establish territory and settle in familiar surroundings. (Greenwood, 1980)

Among mammals, the predominant dispersing sex is male.

Most mammals are polygynous, less territorial. more intense competition for females, better opportunity to disperse and find mates.

Sex-biased Dispersal in the Contemporary United States

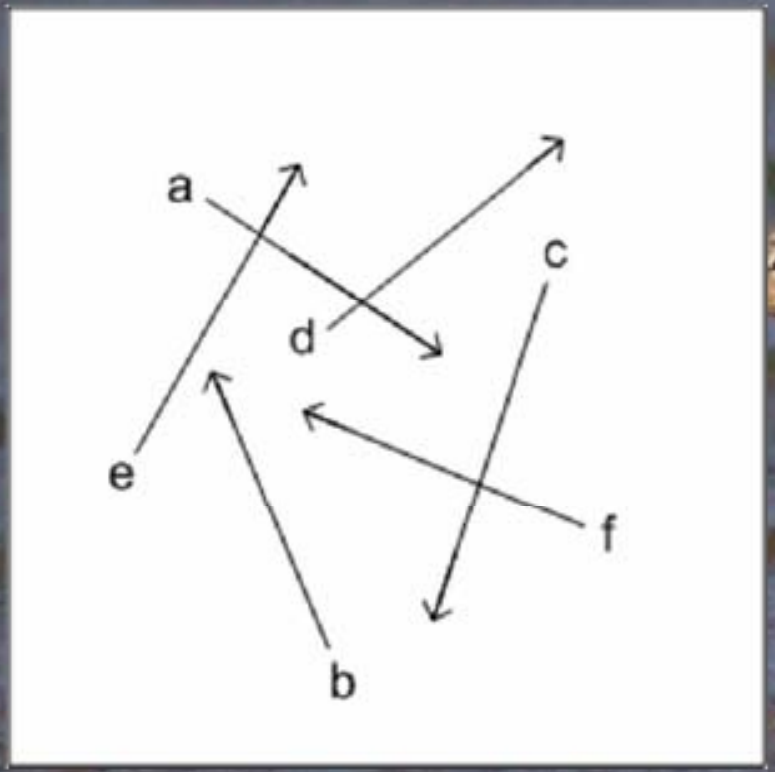
Females in the contemporary United States disperse farther and are less philopatrlc than males, a pattern rare among mammals. This difference occurs primarily during the period of first independence following graduation from high school. I examine the patterns and possible causes of sex bias in internal migration using data derived from high school reunion booklets and a survey conducted on a sample of individuals selected from reunion booklets. The bias, which is small but significant, is largely eliminated when locality and socioeconomic factors are controlled. This suggests that these factors affect the sexes differentially. In general, females who move away to college or obtain jobs that are important to their residence are more likely to disperse relatively long distances, while males appear to be more constrained in their dispersal patterns. Female-biased dispersal (virilocal residence) in many non-industrialized human societies is apparently a consequence of differences between the sexes in patterns of resource accumulation, exemplified by patrilinial inheritance. Similar differences still characterize, to a lesser extent, modern industrialized societies, and may be responsible, at least in part, for the pattern of sex-biased dispersal found in this study.

What is animal migration ?

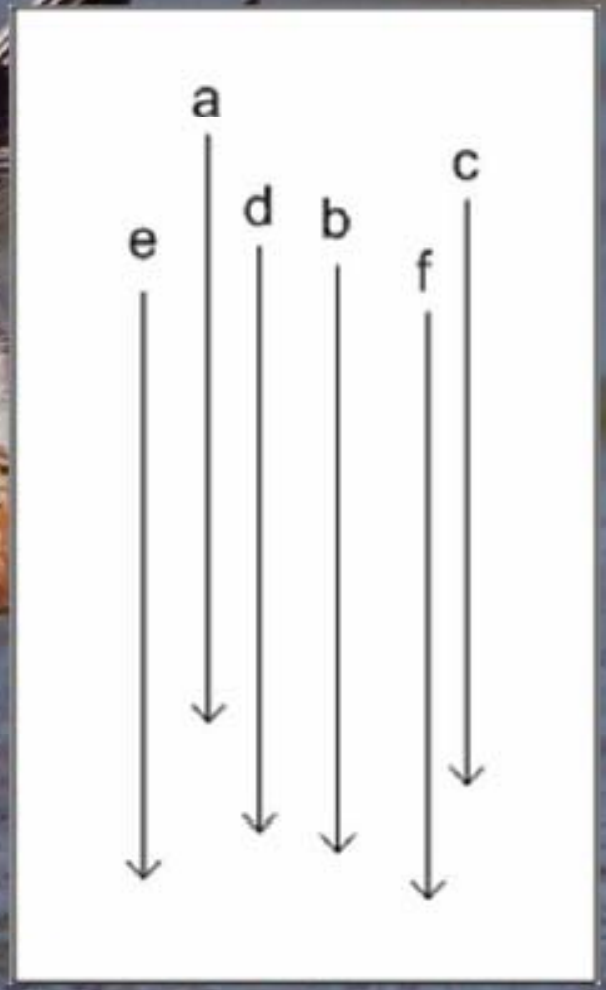
A form of dispersal, movement away from and subsequent return to the same location on an annual basis.

Migration v. dispersal

Migration: Predictable direction



Dispersal

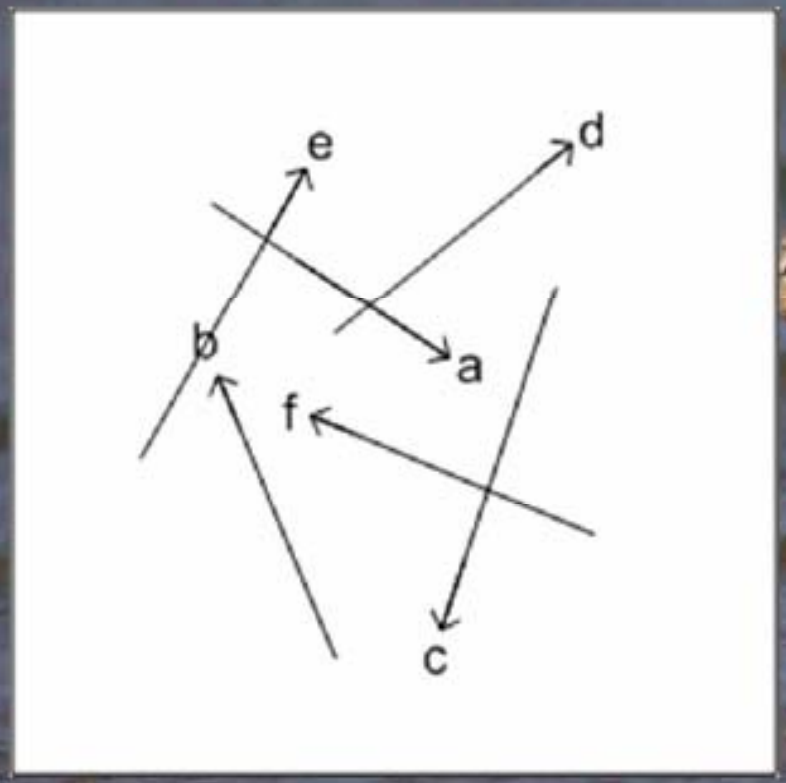


Migration

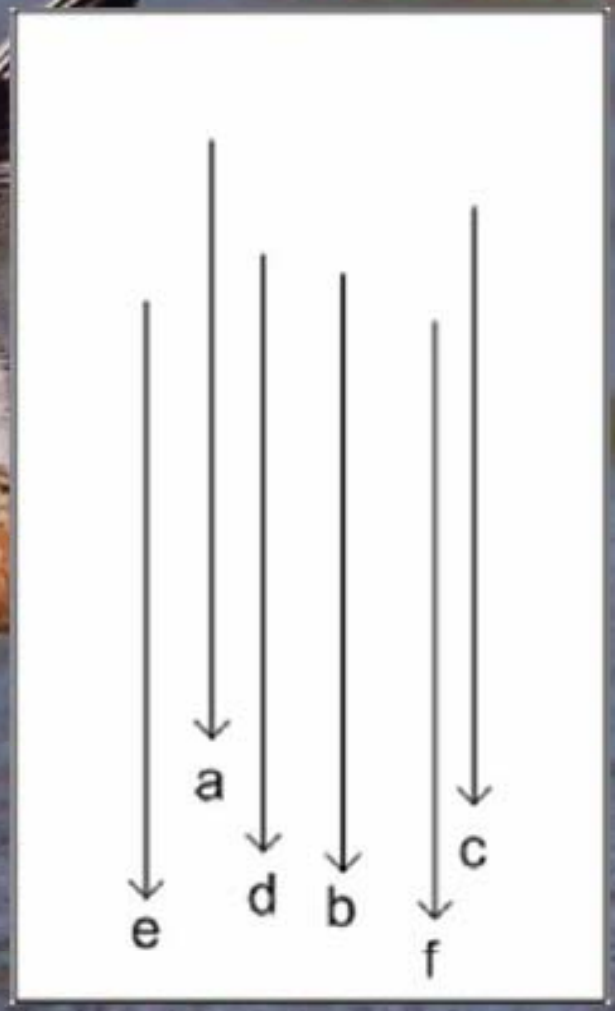
jvverde/Flickr

Migration v. dispersal

Migration: Return to the same area



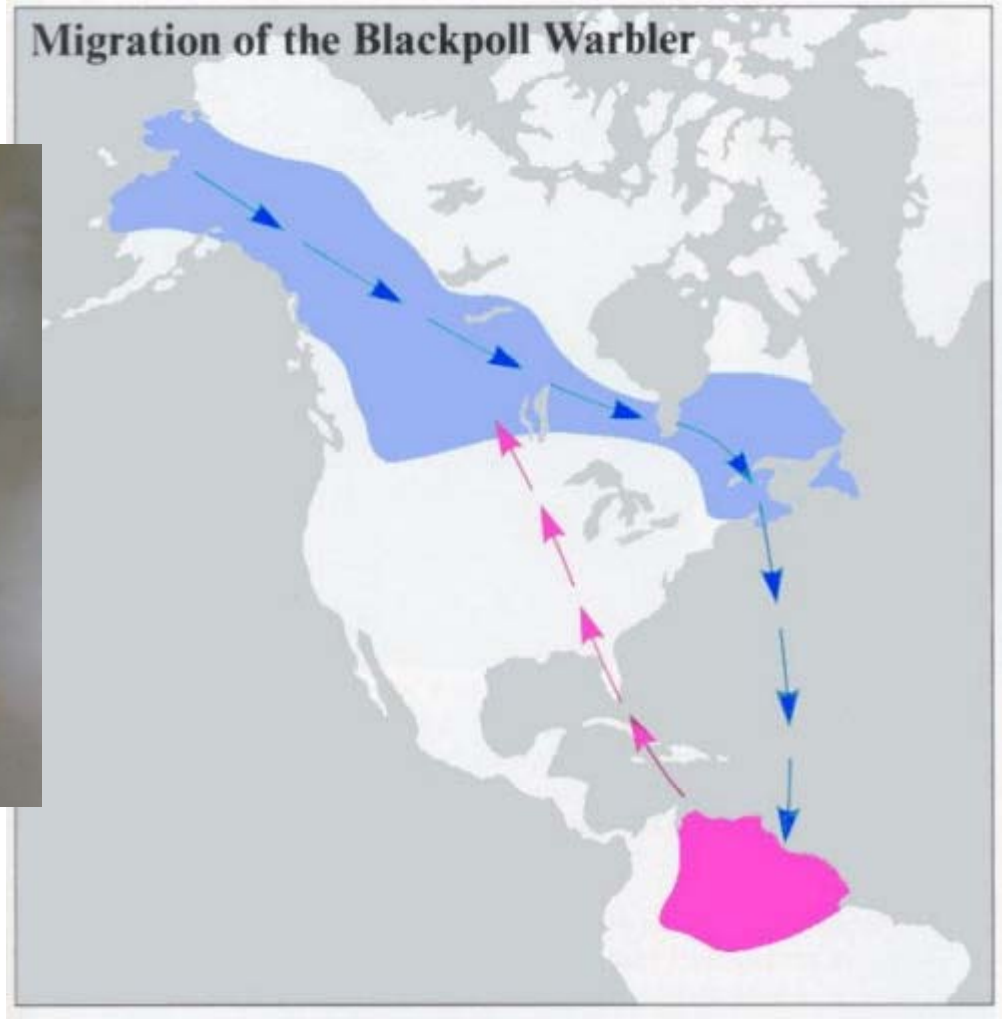
Dispersal



Migration

jvverde/Flickr

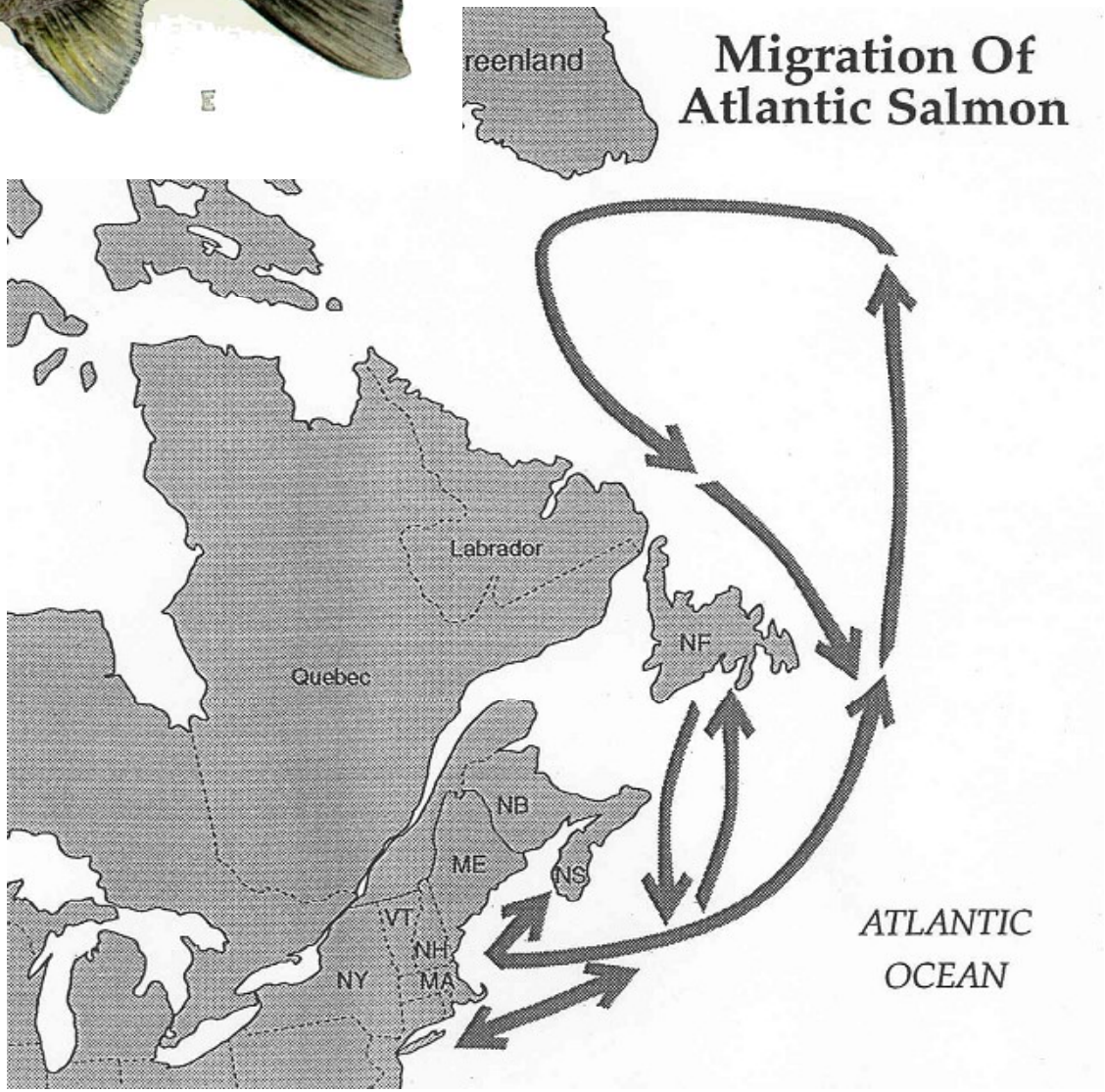
Blackpoll Warbler



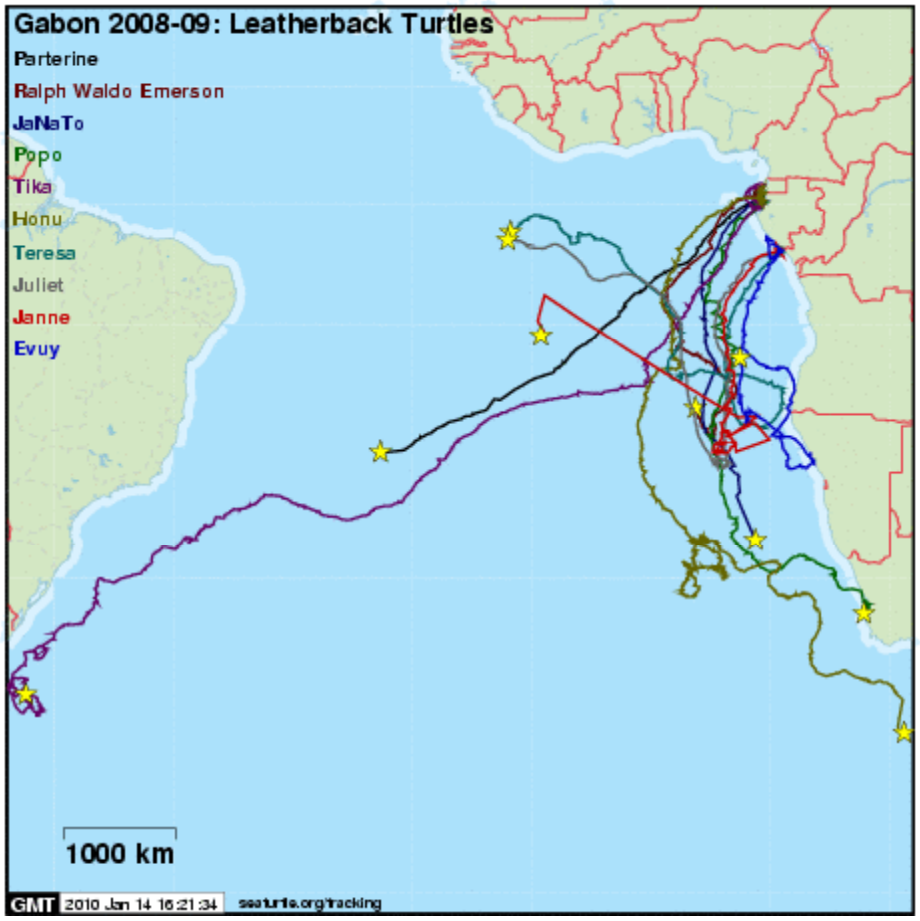
Nearly half of all the breeding birds in NA are migrants

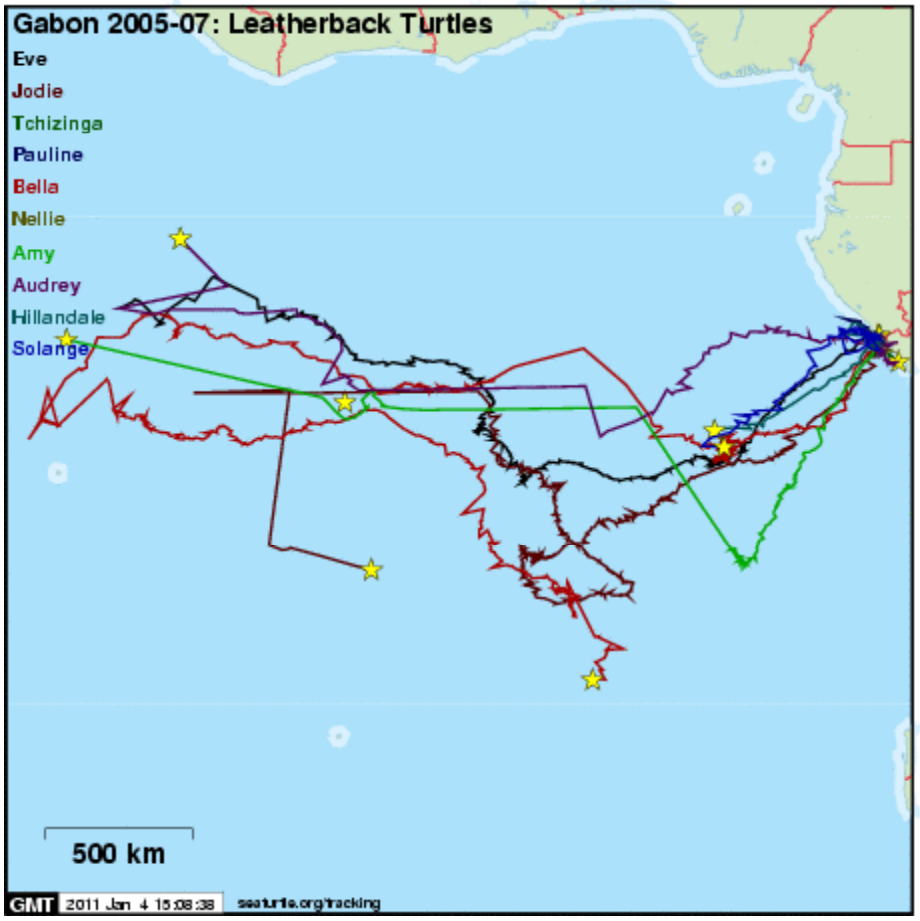
The animals kingdom's longest migration award goes to the Sooty shearwater-----39,000 miles

Atlantic Salmon

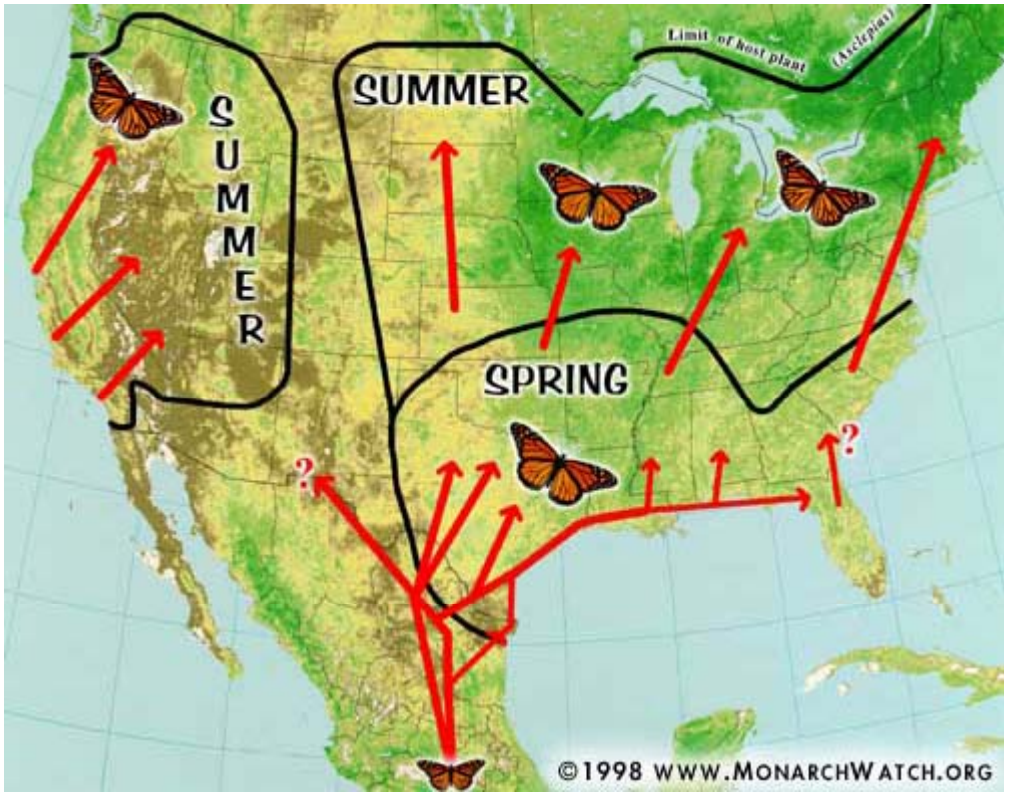


Loggerhead sea turtle





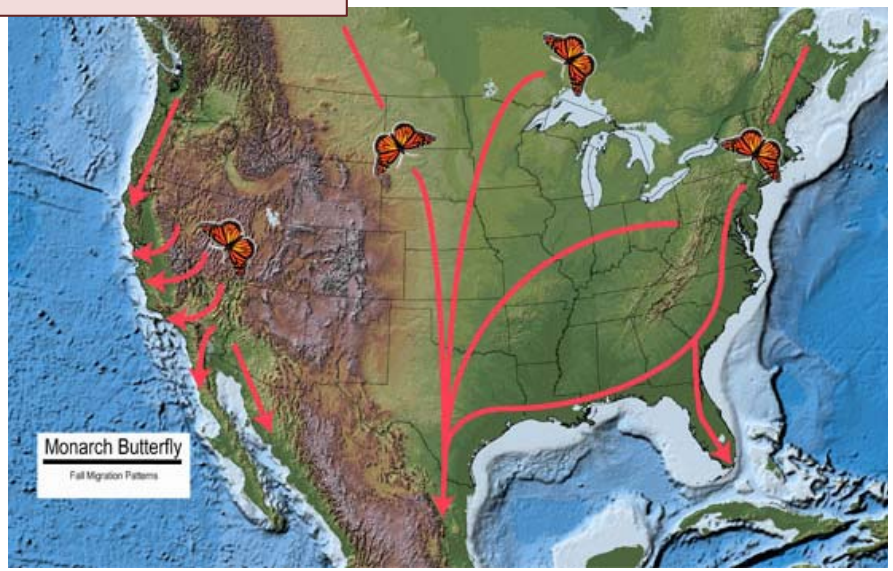
Monarch butterfly: 3000 miles, multi-generation migration



Travel South (fall): One generation

Eastern North American monarchs fly south using several flyways then merge into a single flyway in Central Texas.

3600km in 75 days: 50km per days



Wintering

Overwintering Monarchs clustering on Oyamel trees (2500-3500 m height) in Angangueo, Michoacan, Mexico.


George D. Iepp

Travel North (spring): 2-3 generations

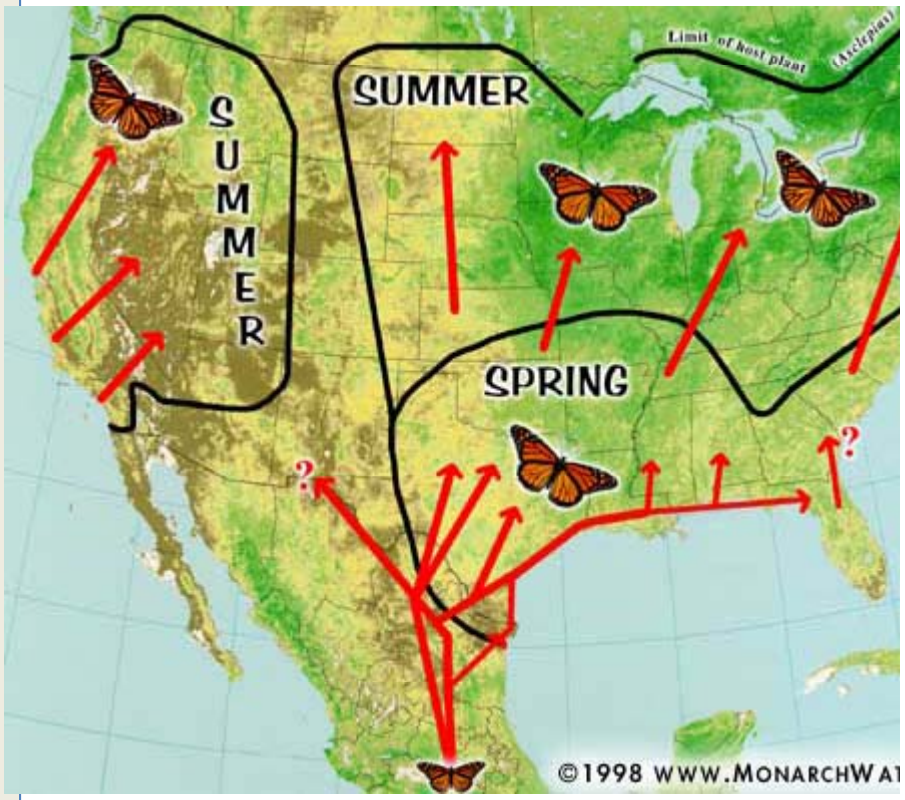
First generations:

Early spring, to gulf coast, lay eggs and then die.

Offspring of the first generation → Second generation: migrate to Great lake and southern Canada; lay eggs and then die

Offspring of the second generation → third generation: migrate to east; lay eggs; then die

Offspring of the third generation →fall migration back south




The New York Times
Science
October 3, 2006

1. Monarch Butterfly migration:
   Can each butterfly make a complete migratory round trip?

2. How do Monarch Butterflies navigate?

3. Is this migratory behavior innate or learned?

4. What is their main food resource? How it is important for their migration/ survival?

5. What factors make them endangered?

Why do animals migrate?

Ultimate causes?

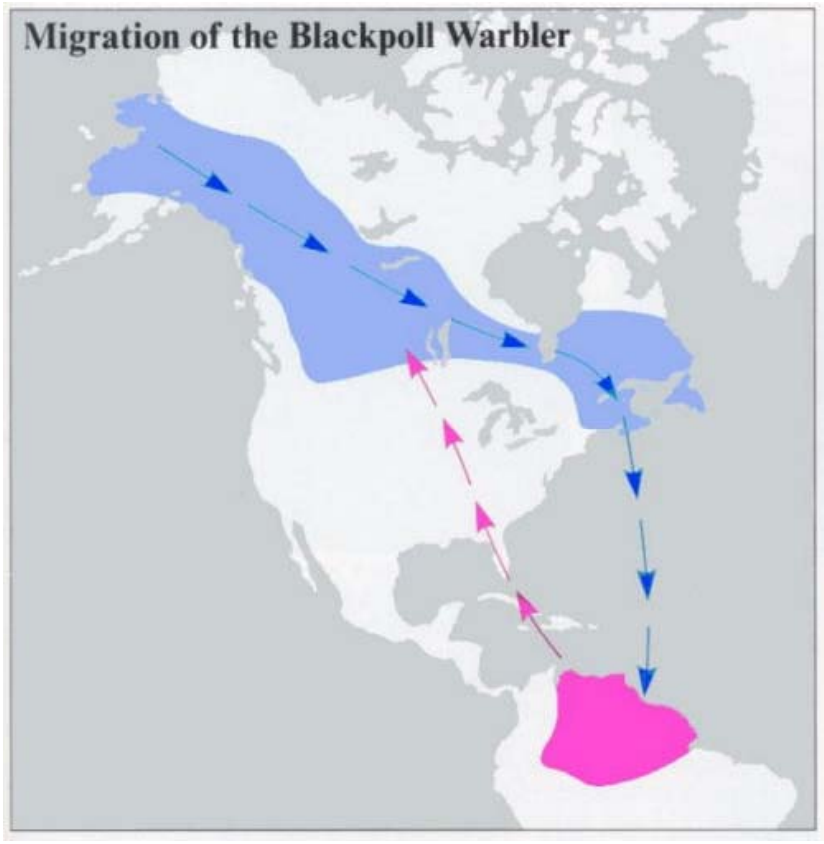
Why do animals migrate?

The **benefits** of migration: food and reproduce

1. Abundant food in the north (temperate zone) during summer (insects…).
2. Less predators in the north during summer.
3. Longer hours of summer daylight in the north than staying in tropics.
4. Warmer temperature for wintering in tropics.

The potential costs of migration

1. Require energy: large fat reserve
2. Predator



Why do animals migrate?

The costs of migration

1. Energy: large fat reserve
2. Predator

Many predators wait at migratory stopover sites to capture exhausted migrants

Migratory behavior:

learned or innate?

Blackcaps

Blackcaps: an European warbler

Population #1: fully migratory (central Europe), why migrate?

Population #2: non-migratory; resident all year long (an island close to Africa), why residential?

How do you design an experiment to determine if this migratory behavior is innate or learned?

Blackcaps: an European warbler

Population #1: fully migratory (central Europe)

Population #2: non-migratory; resident all year long (an island close to Africa)

Cross-breed between migratory and non-migratory birds

What are your predictions??

Cross-breed between migratory/ non-migratory birds

What are your predictions??

*If it is a learned behavior, then we predict the hybrid offspring (F1) can either be fully migratory or fully residential, depends on where it is hatched.

*If it is an innate behavior, then we predict the hybrid offspring (F1) will have some degree of migratory behavior, no matter where it is hatched

Blackcaps: an European warbler

Population #1: fully migratory (central Europe)

Population #2: non-migratory; resident all year long (an island close to Africa)

F1 hybrids (fully migratory x resident) = 40% are migratory
Demonstrate that genetic basis of the migratory behavior

Not all of F1 become migratory: not a single genetic locus determines this behavioral trait.

Blackcaps: Experiment #2

Two populations; both are migratory, both are from central Europe.

But have different migratory routes:

Population 1: southwest route

Population 2: southeastern

How do you design an experiment to determine if the migratory behavior is innate or learned?

Cross-breed between southwesters and southeasterns

And your predictions??

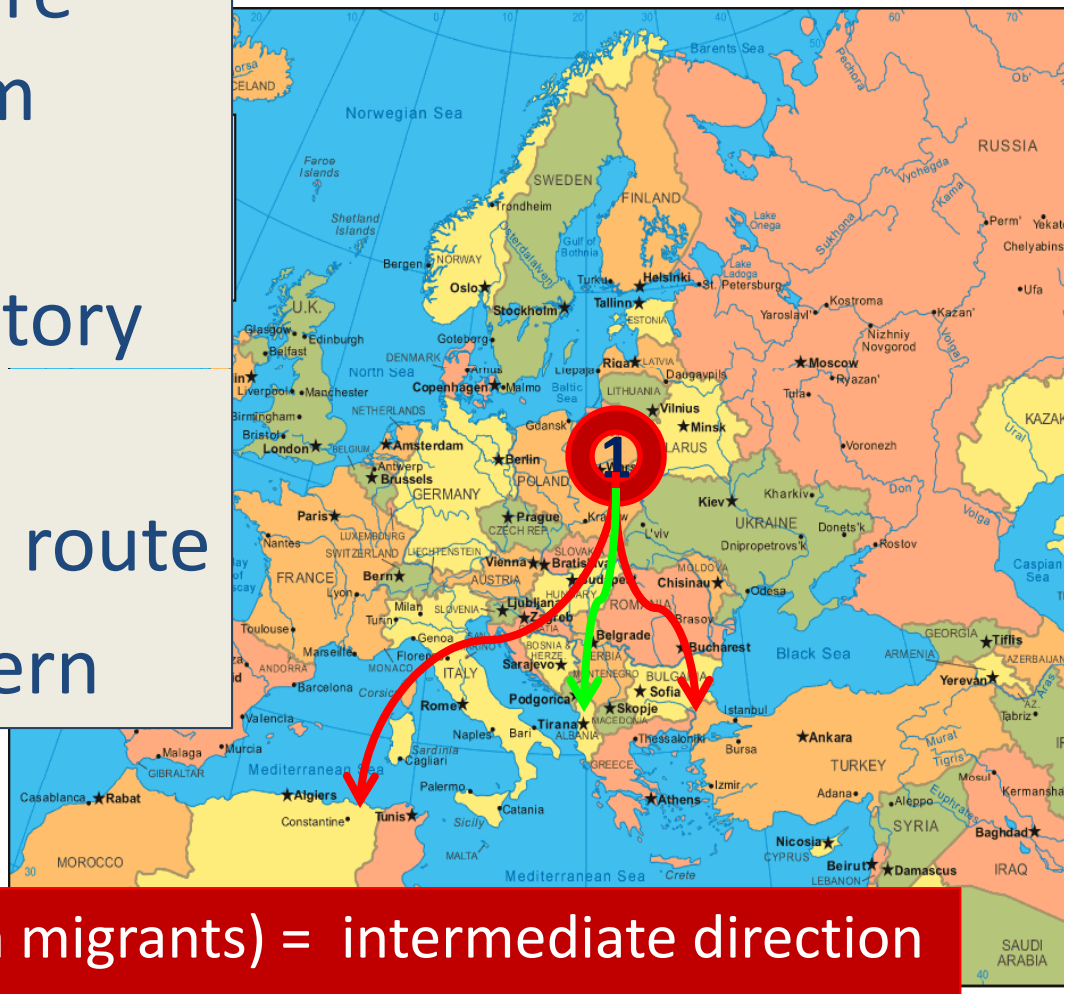
Blackcaps: Experiment #2

Two populations; both are migratory, both are from central Europe.

But have different migratory routes:

Population 1: southwest route

Population 2: southeastern



F1 hybrids (eastern x western migrants) = intermediate direction

Demonstrate that genetic control of the migratory behavior

Blackcaps

Not only the direction, but also distance is under genetic control

Migratory distance is under genetic control, how do you measure the flight distance?

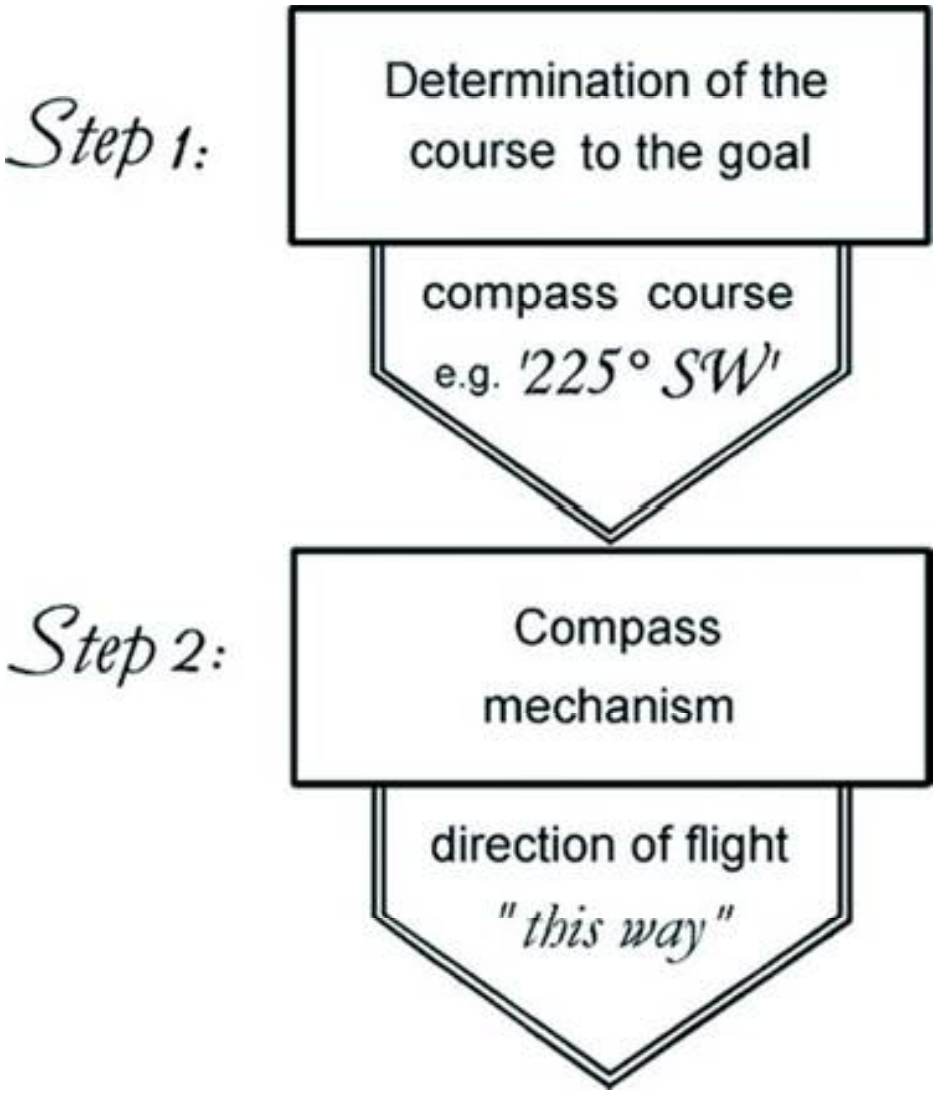
Flight restlessness occurs at the time when birds migrate, the longer the migration route is, the longer the flight restlessness lasts when the bird is kept in the cage

Measure flight restlessness
(wing-flapping toward the same direction)

Proximate mechanisms of migration: How do animals migrate? (you need to know where you are, and where are you going to)

Orientation: determine compass direction
Navigation: judge the position while traveling

Orientation and Navigation

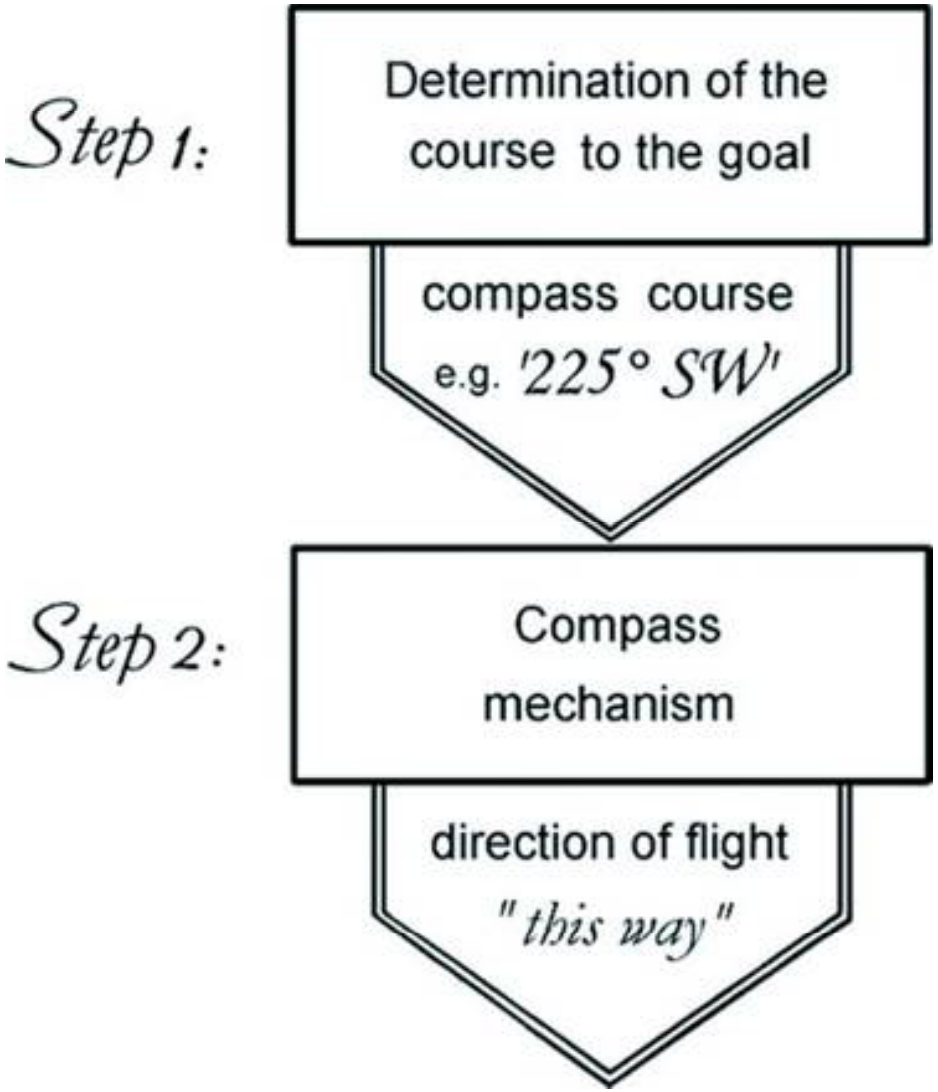


Central Park

BHSEC, Queen


central park relative to BHSEC
Navigation : correcting the direction when going toward central park
Central Park
BHSEC, Queen
Manhattan
Upper East Side
Central Park
Ditmars Steinway
LaGuardia Airport
Clinton
Midtown Center
Astoria
Jackson Heights
Long Island City
Elmhurst
Maspeth
5th Ave
FDR Drive
E 34th St
25
278
495

Proximate mechanisms of migration: Navigation



1. Landmark
2. Sun compass
3. Star compass
4. Polarized light
5. Magnetic field
6. Odor

1. Landmark
-useful for short distance navigation

Design an experiment to determine how landmark guide navigation?

2. Sun Compass

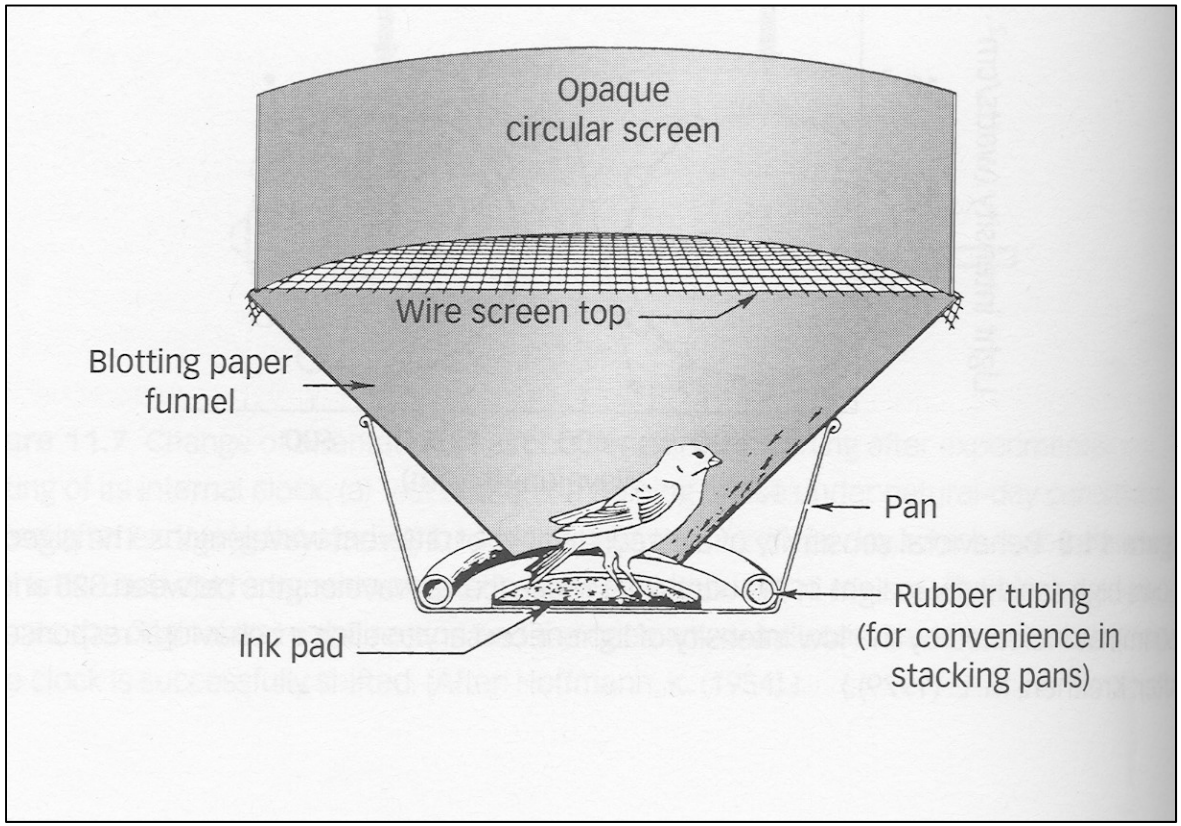
Sun compass: animals can use the position of the sun for orientation

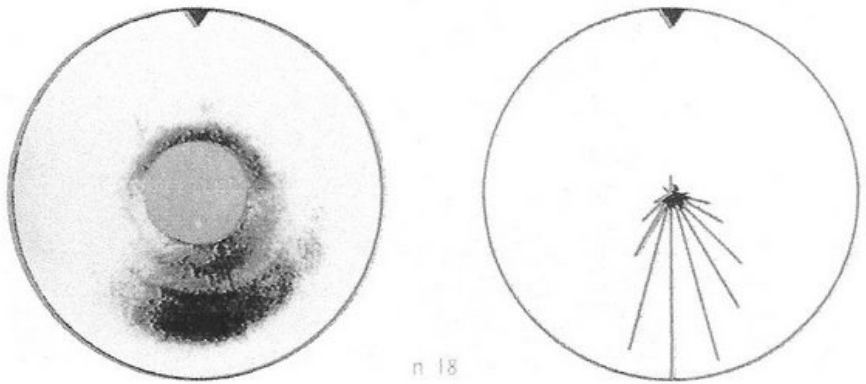
Design an experiment to determine how sun compass guide migration?

1. To test if birds use sun compass

During the migratory season, keep migratory birds in cages, where they can see the sun, record the direction and flight restlessness at the time they usually migrate.

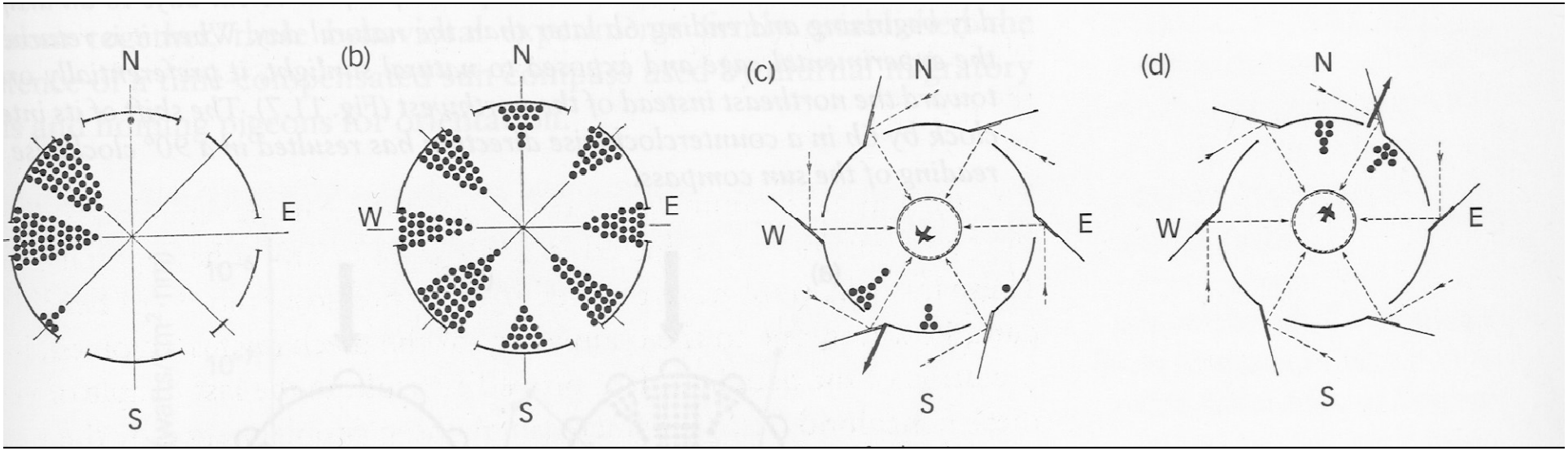
1. Laboratory setup to test orientation





European starling

Sun compass

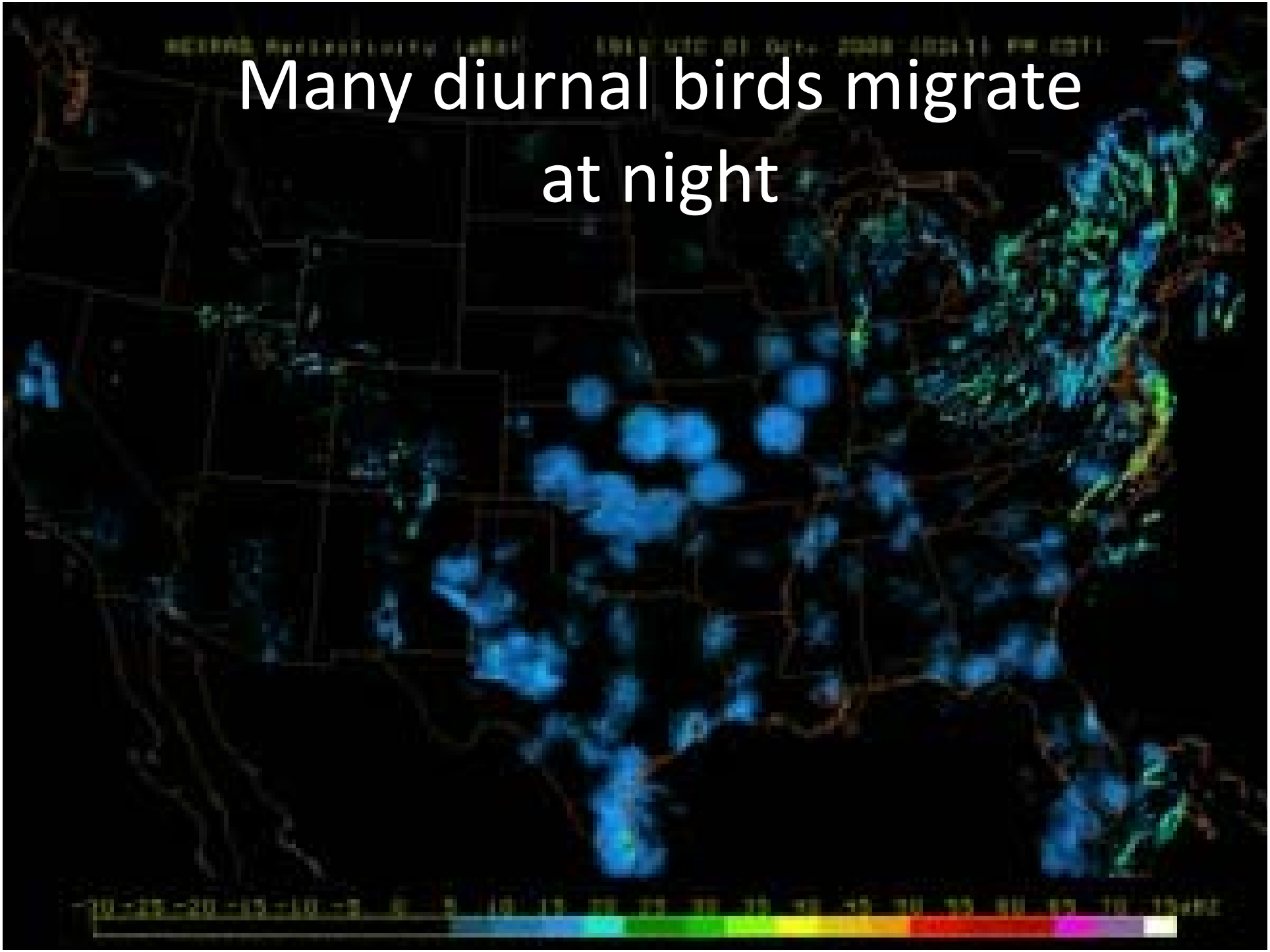


Sun | Overcast | Mirror-deflected 90 degree | Mirror deflected 90 degree

Many diurnal birds migrate at night

William Cochran (1967) captured a migrating Gray-cheeked thrush in Illinois and attached a tiny radio transmitter to it. At dusk, the thrush took off, followed by the ornithologist in a small plane. A severe thunderstorm and shortage of fuel forced their plane down that night, but the thrush flew on. After refueling, they relocated the bird in the vast night sky. The thrush landed at dawn in Wisconsin after flying 650 km on a firm compass bearing all night.

Many diurnal birds migrate at night



How do nocturnal migrants migrate at night (and use what cues) ?

Keep the migrants in cages:

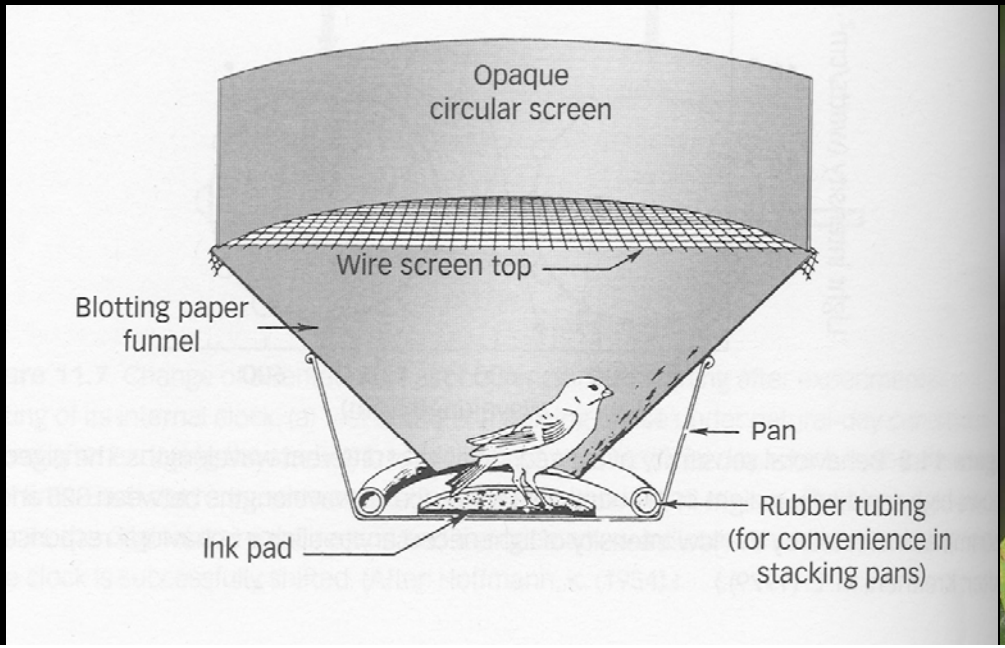
1. When kept indoors, not seeing the sky they seem disoriented.
2. When kept in the same cage outdoors, they could see the sky. They are oriented!

Star compass

Design an experiment to test birds can use "star compass".

Keep the migrants in a cage (ink pad on the bottom):

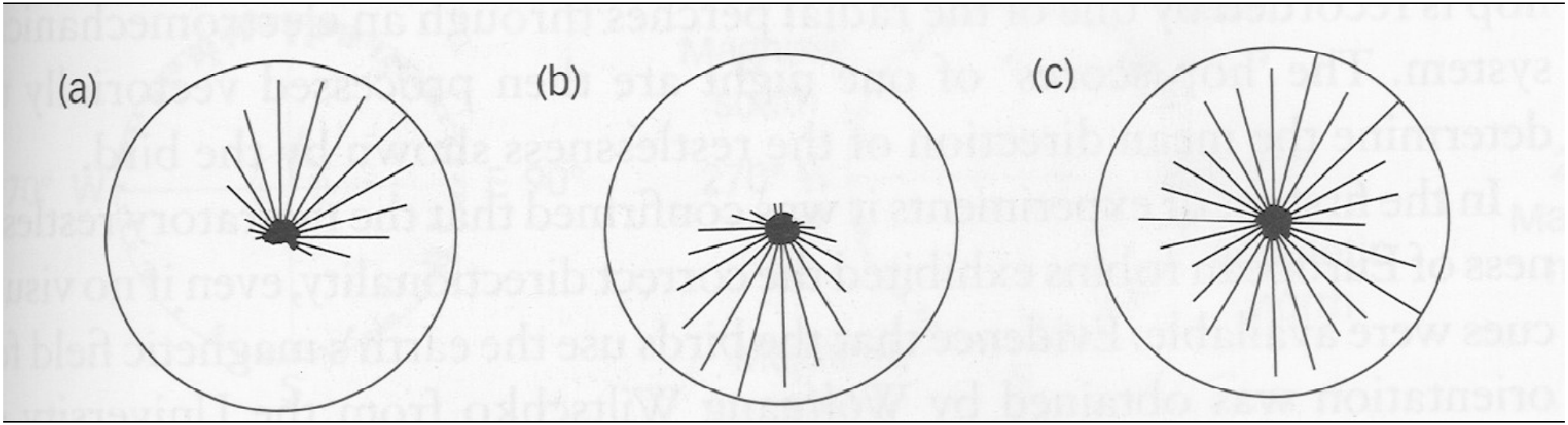
1. Birds oriented under natural night sky.
   (not good enough test)



Or, use planetarium

Keep the migrants in a cage:

1. Birds orient under natural night sky
2. Birds oriented the same direction under the stationary sky of a planetarium.



Spring planetarium sky	Spring planetarium sky, rotate 180 degree	Control group, No star.

Birds learn to recognize

star compass

Juveniles learn to read the star compass in a “sensitive period” before migration

Sun and star compass used to determine the direction of orientation.

Many migratory birds maintain the correct orientation, even if the sky is obscured by clouds (can’t read sun or stars)

Magnet compass

Figure 1 | Animal magnetism. Diverse species have magnetic compasses, including (clockwise from top left) the European robin, the loggerhead sea turtle, the brown bat, the Caribbean spiny lobster and the red-spotted newt. A few, including turtles, lobsters and newts, also have magnetic maps.

Cows can sense magnetic field

Researchers have found that when grazing or resting, cattle and deer tend to point their bodies toward Earth's magnetic poles, which suggests they are able to sense magnetic fields in the same way as many smaller animals.

German and Czech researchers used Google Earth satellite images to look at 8,510 domestic cattle in 308 pastures located randomly across six continents. They also studied body alignment in 2,974 red and roe deer in the Czech Republic, either by photographing the animals or checking the impressions they left in snow.

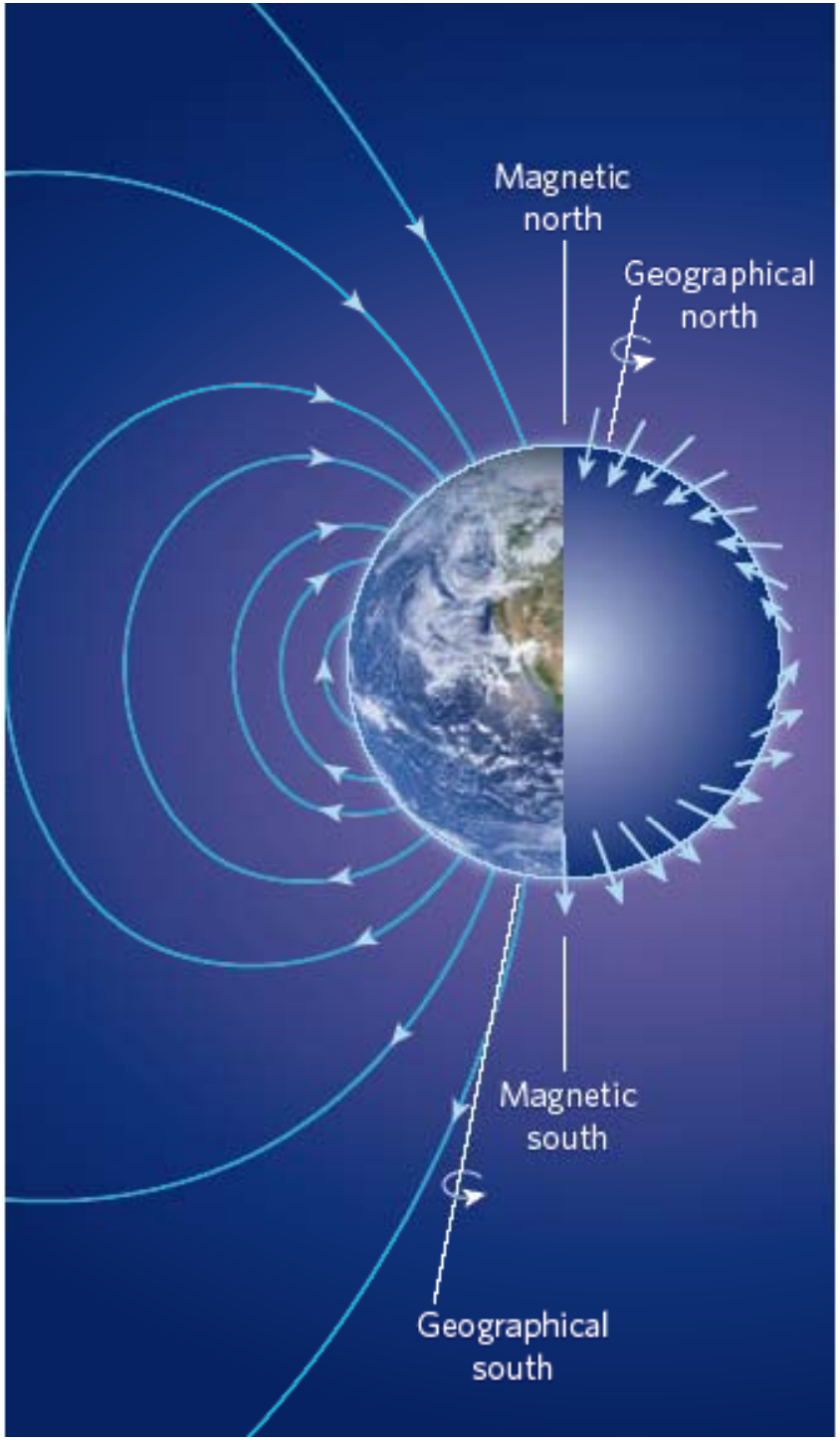
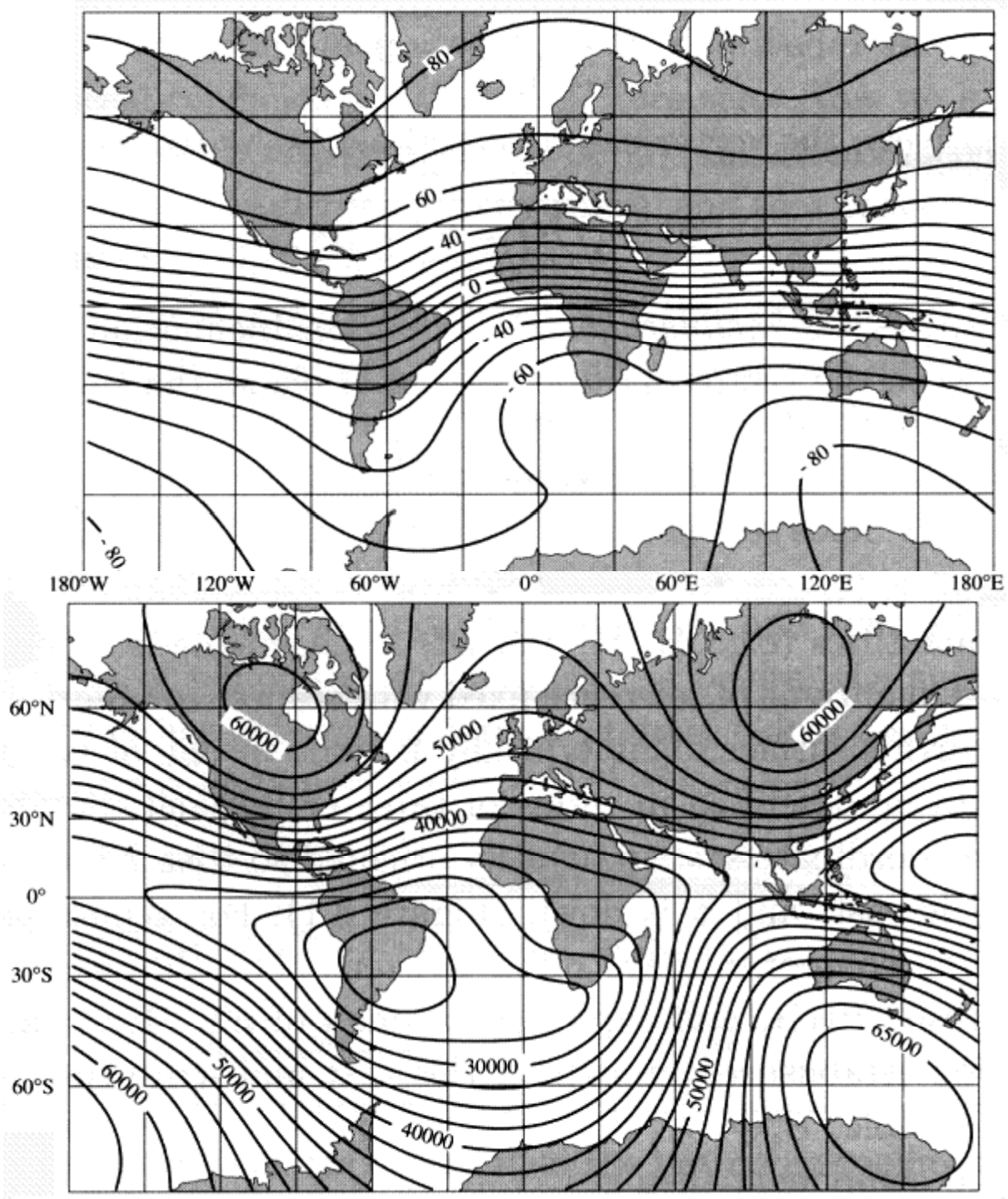
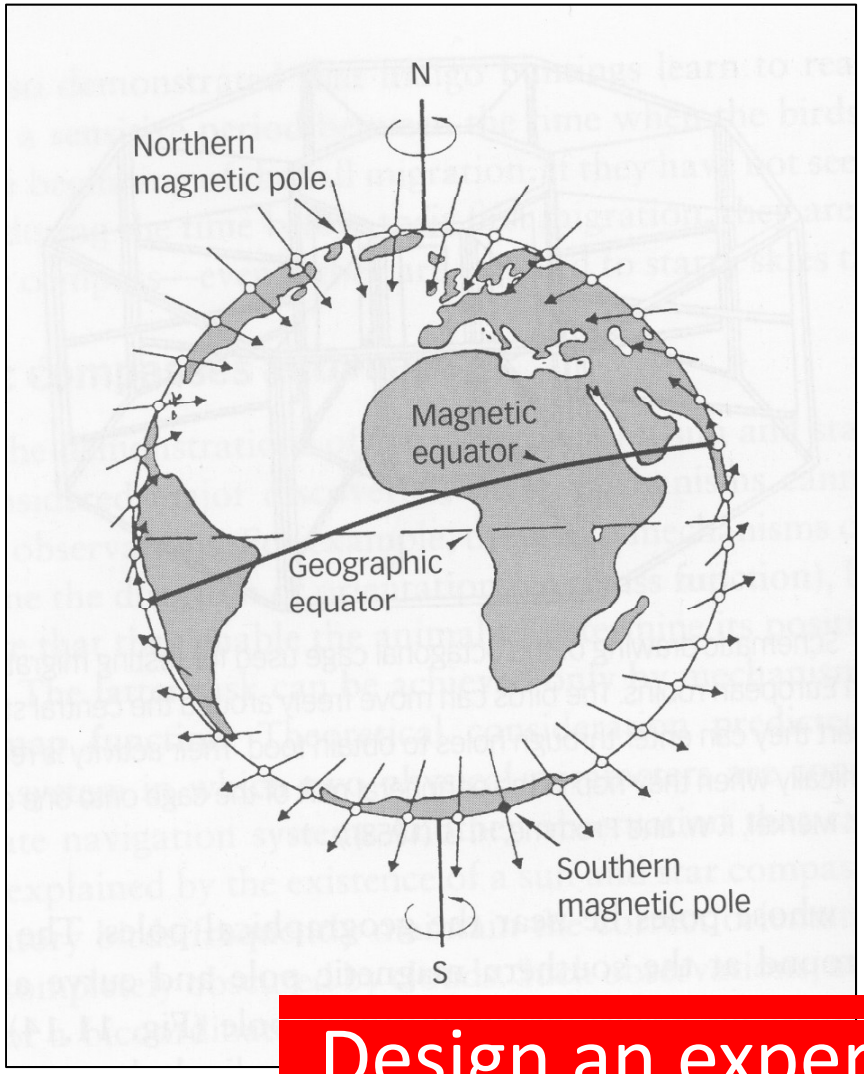


Figure 2 | Earth's magnetic field. Field lines emerge from the Southern Hemisphere, wrap around the globe, and re-enter Earth in the Northern Hemisphere. Field lines are parallel to Earth's surface at the geomagnetic equator, but become progressively steeper as an animal migrates towards the poles. Field intensity also varies predictably across Earth's surface. Thus, different geographical regions often have unique 'magnetic signatures' consisting of specific combinations of field-line inclination and intensity, as indicated by the angle and length of the arrows on the right. Animals that have magnetic maps can exploit such information when navigating to particular areas. (Reproduced from T. Alerstam *Nature* 421, 27–28; 2003.)

Magnetic signature

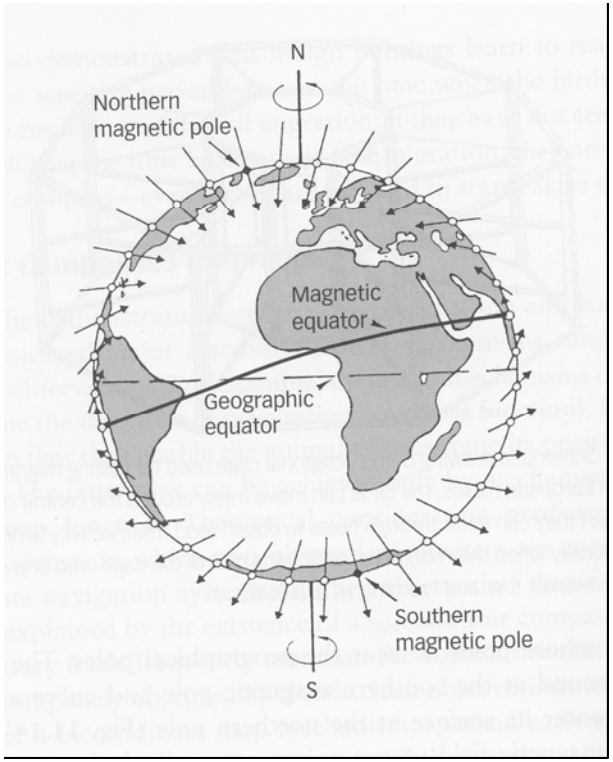


Magnet compass



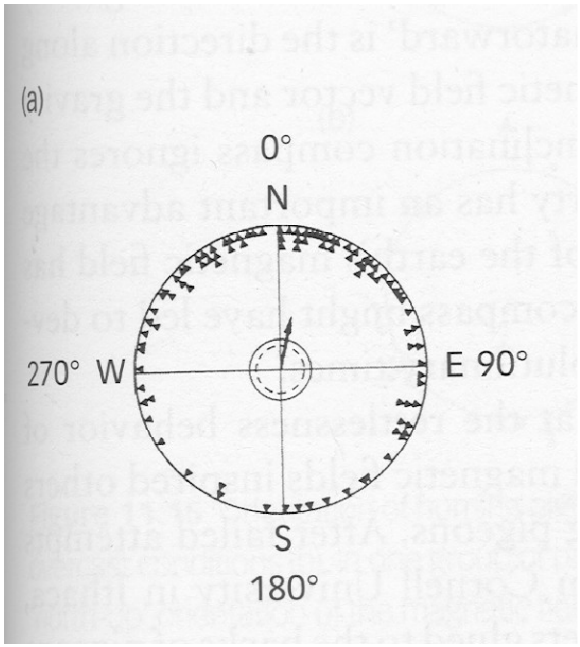
Geographic north/south
is different from
Magnetic north/south

Design an experiment to determine if magnetic field guides orientation?



Magnet compass

Change the magnetic field, birds change their orientation

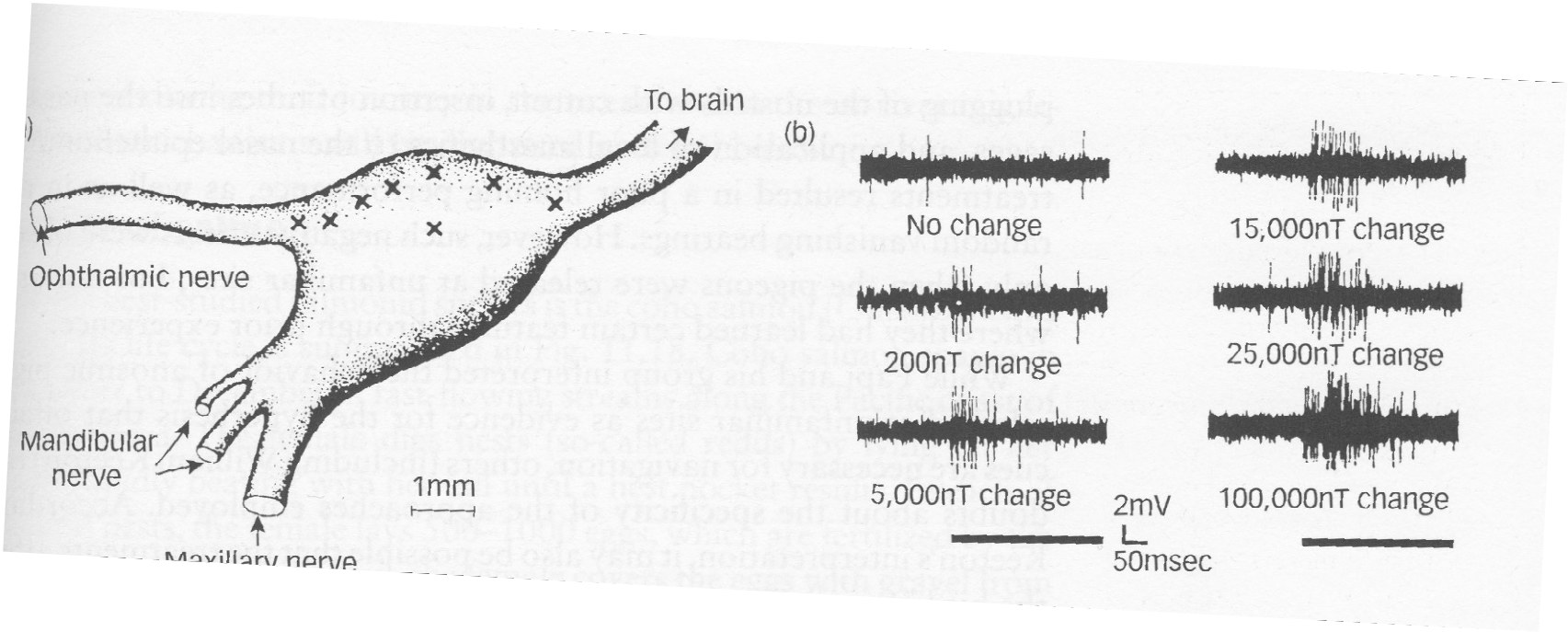


How do animals perceive magnetic field?

1. Magnetic particles (magnetite)

2. Cryptochrome
   (light-photoreceptor protein)

Many animals have magnetic particles in the neurons to detect the magnetic field



Olfactory map:
smell their way home

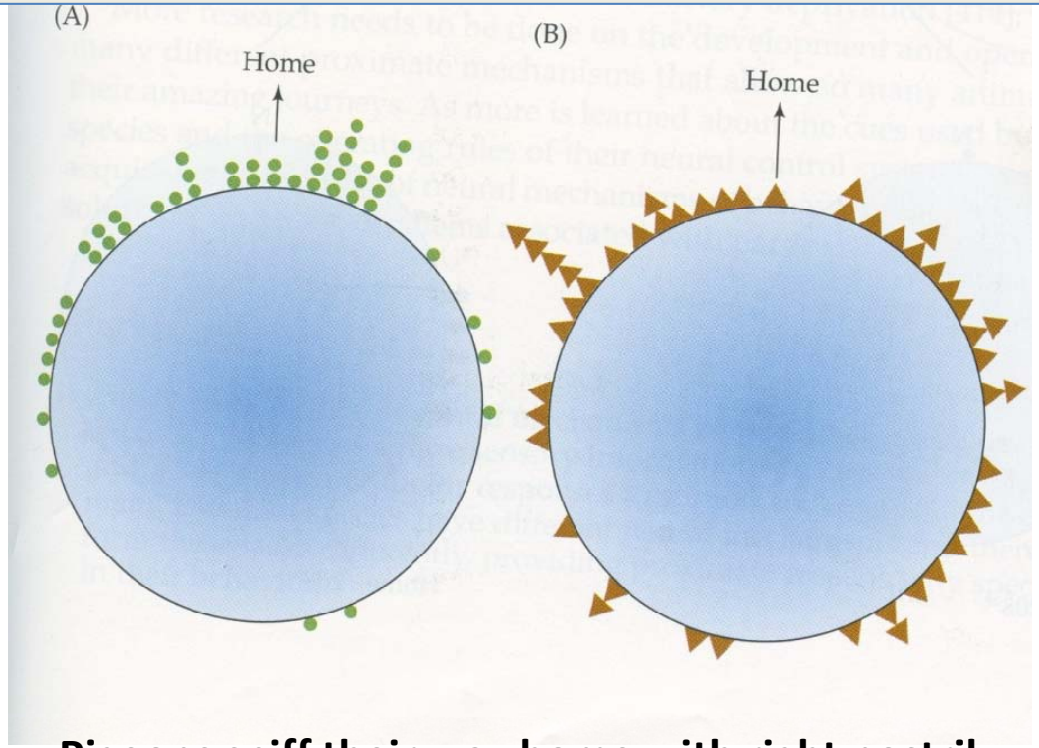
Different locations have different odors;

A north wind and a west wind would each have a distinctive odor

Design an experiment to determine if olfactory map guides orientation?

Olfactory map:

Pigeons with blocked olfaction were much less likely to orient accurately toward the home loft on release

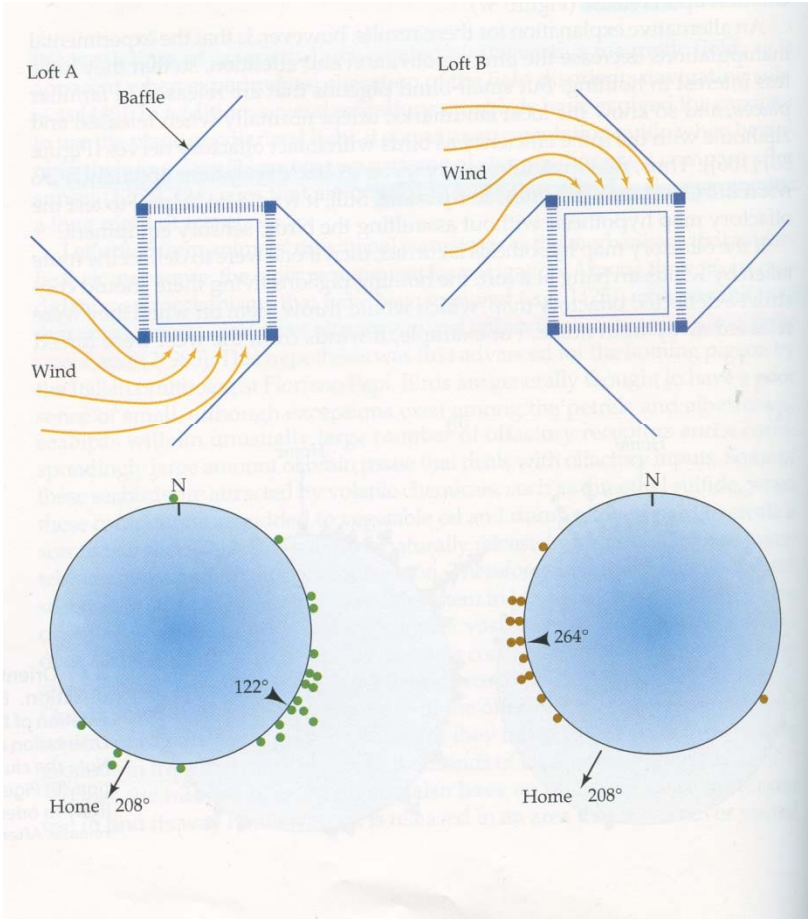


Pigeons sniff their way home with right nostril

Further test of olfactory hypothesis

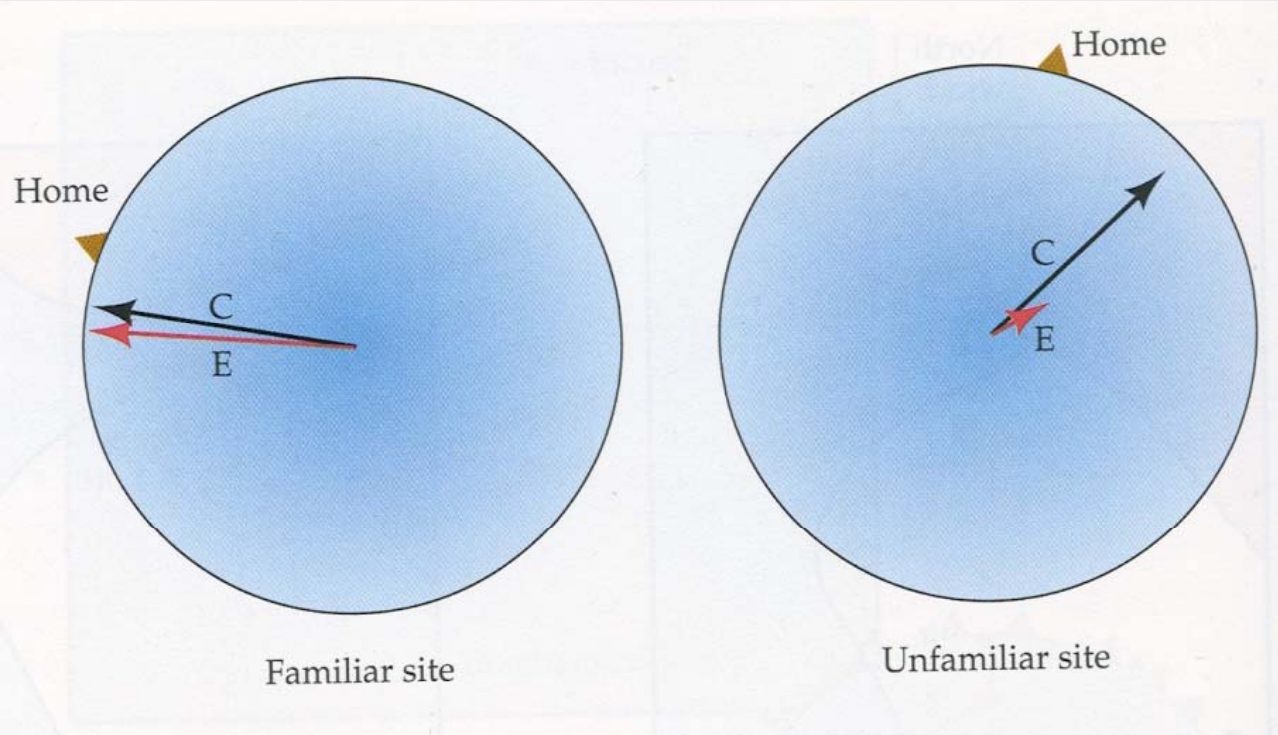
Baffles deflect the wind 90 degree,

alter pigeon's perceptions of the direction of odors



However,

The effect of blocking olfaction on orientation occurs only if pigeons were released at an unfamiliar site.



Conclusion:

Many animals can use a combination of compass for orientation or migration.

Sun compass

Star compass

Polarized light

Magnet compass

Olfactory map

Landmark

Human navigation

Sun compass

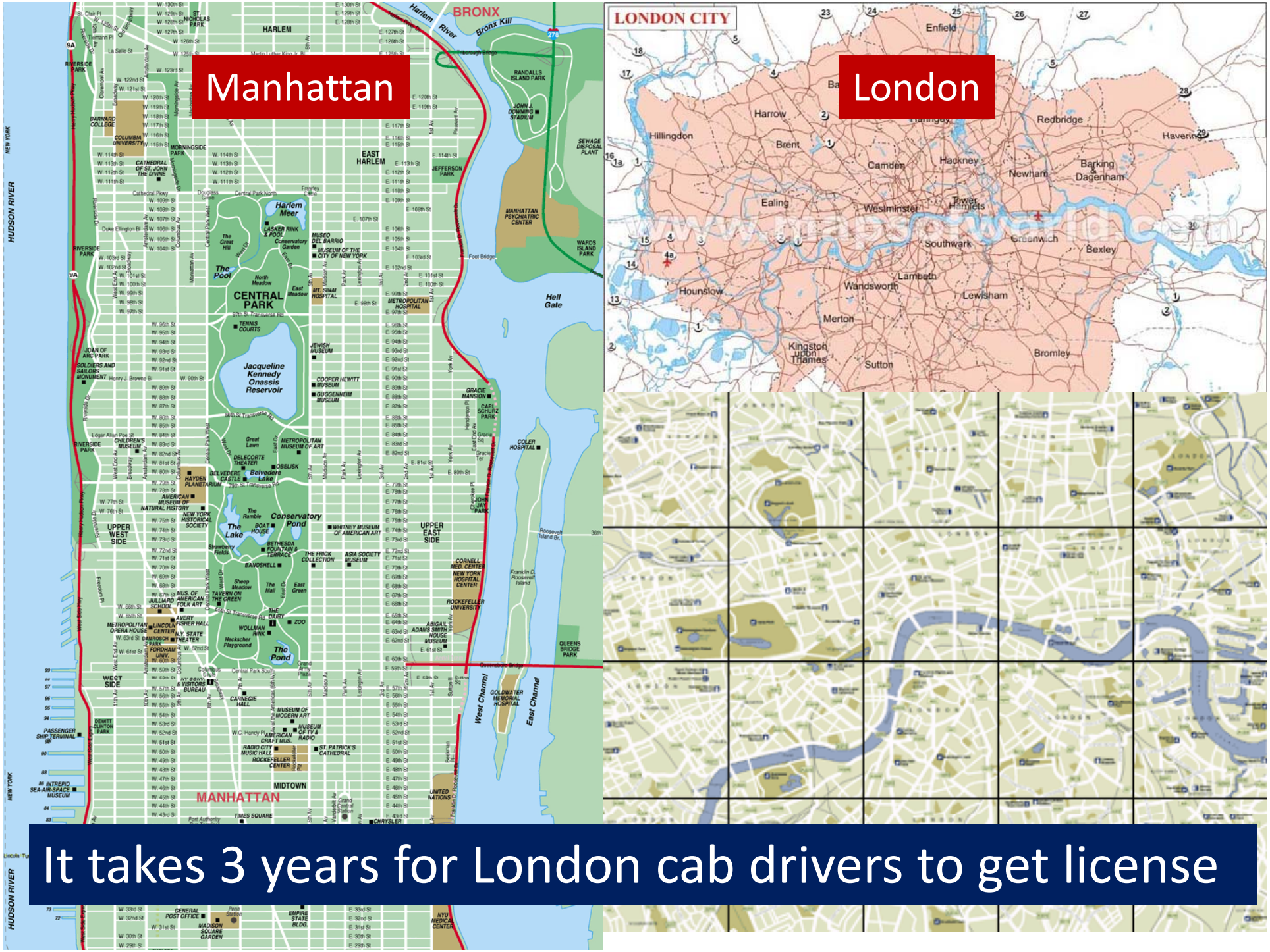
Star compass

Polarized light

Magnet compass

Olfactory map

Landmark



It takes 3 years for London cab drivers to get license

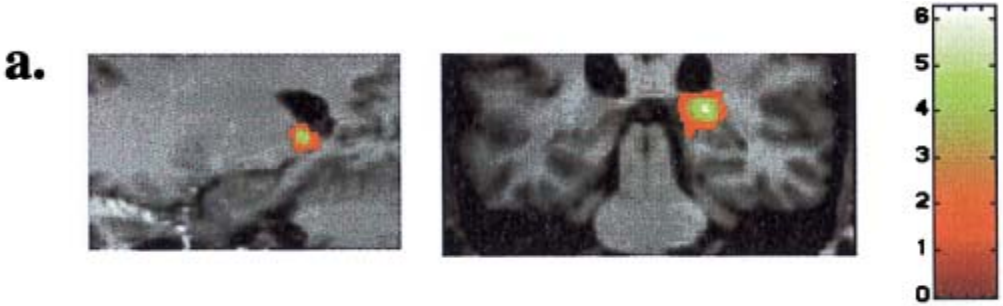
Taxi drivers' brains 'grow' on the job

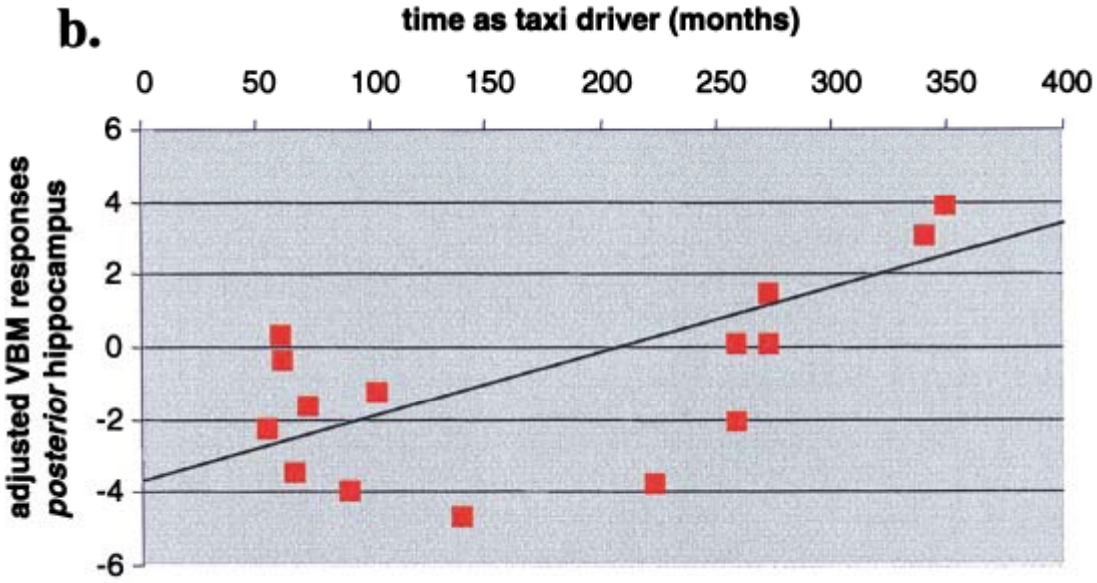
Taxi drivers given brain scans had a larger hippocampus compared with other people, part of the hippocampus grew larger as the taxi drivers spent more time in the job

Navigation-related structural change in the hippocampi of taxi drivers

Eleanor A. Maguire*†, David G. Gadian‡, Ingrid S. Johnsrude†, Catriona D. Good†, John Ashburner†, Richard S. J. Frackowiak†, and Christopher D. Frith†

†Wellcome Department of Cognitive Neurology, Institute of Neurology, University College London, Queen Square, London WC1N 3BG, United Kingdom; and ‡Radiology and Physics Unit, Institute of Child Health, University College London, London WC1N 1EH, United Kingdom





Scientists used to think human brains would not grow new neurons as adults.

But now we know we do grow new neurons as adults, and…

The more you use your brains,
the more new neurons you grow,
and the healthier you are.